

Hydrogen Fuel Cell Electric Vehicles: Future of Sustainable Mobility

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ABSTRACT

Electric vehicles or referred to as EVs, are the future of mobility. They aid in reducing vehicle pollution and pave the way to a cleaner and greener environment. However, technology is something that gets advanced with each passing day. The next personification of electric cars is the hydrogen fuel cell vehicle. They have a close resemblance to EVs, but the working principle is entirely different.

Like all electric vehicles, fuel cell electric vehicles (FCEVs) use electricity to power an electric motor. In contrast to other electric vehicles, FCEVs produce electricity using a fuel cell powered by hydrogen, rather than drawing electricity from a battery.

KEYWORDS: Fuel cell electric vehicles (FCEVs), Hydrogen fuel cells (HFCs), Battery electric vehicles (BEVs)

How to cite this paper: Rujuta Omkar Kambli "Hydrogen Fuel Cell Electric Vehicles: Future of Sustainable Mobility" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-3, June 2023, pp.174-177, URL: www.ijtsrd.com/papers/ijtsrd56324.pdf



IJTSRD56324

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Working of Hydrogen fuel cell electric vehicles:

Hydrogen fuel cell vehicles are similar to electric cars [1]. Both use an electric motor for propulsion instead of an internal combustion engine. But the similarities end there because an EV needs an external power source to recharge the battery. In contrast, a hydrogen-powered vehicle can generate electricity onboard with the help of a fuel cell.

vehicle's fuel cell utilizes hydrogen to produce electricity to power the electric motor.

A hydrogen car also has an onboard battery to store electricity produced by the fuel cell. Typically, the fuel cell directly powers the motor. However, when there is more demand for power, the electricity stored in the battery is utilized.

In the following section, we will discuss the working principle of a fuel cell in an FCEV (Fuel Cell Electric Vehicle).

Hydrogen fuel cells:

Hydrogen fuel cells (HFCs) are a type of electrochemical cell. HFCs generate electricity by reduction and oxidation reactions within the cell. They use three main components, a fuel, an oxidant and an electrolyte [2]. HFCs operate like batteries although they require external fuel. HFCs are a thermodynamically open system. HFCs are hydrogen as a fuel, oxygen as an oxidant, a proton exchange membrane as an electrolyte, and emit only water as waste.

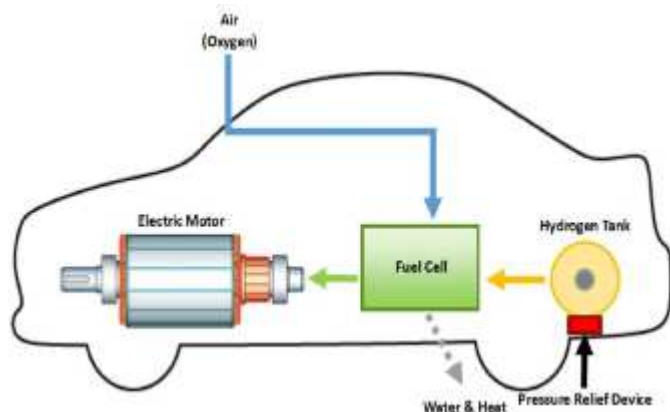


Fig. 1 Hydrogen Fuel Cell Vehicle [1]

Storage of hydrogen in the vehicle:

Like petrol or diesel, one can refuel hydrogen, and it's stored in the vehicle's pressurized tank [1]. The

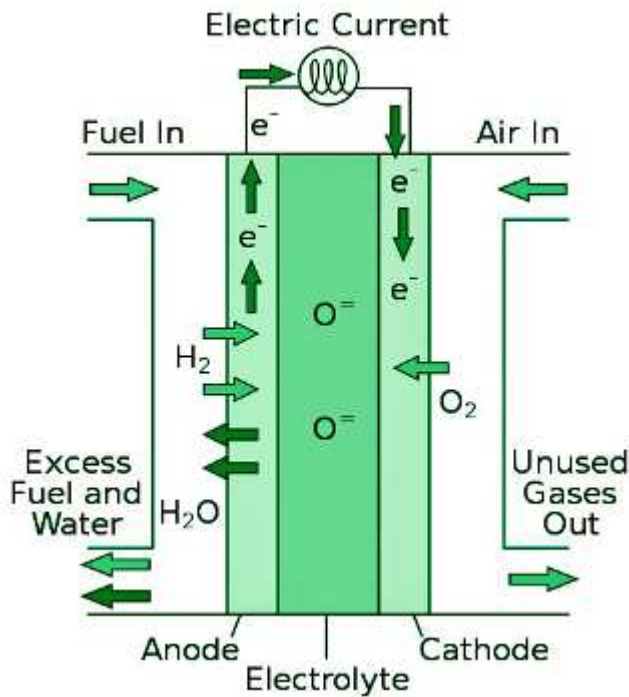


Fig. 2. Fuel Cell [2]

Structure of fuel-cell electric vehicle (FCEV):

All fuel cells are made up of three parts: an electrolyte, an anode and a cathode. In principle, a hydrogen fuel cell functions like a battery, producing electricity, which can run an electric motor [3]. Instead of requiring recharging, however, the fuel cell can be refilled with hydrogen.

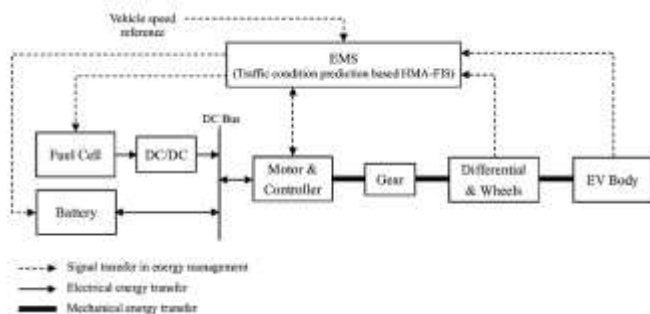


Fig. 3. Structure of fuel-cell electric vehicle (FCEV) powered by fuel cell and battery [3]

Key Components of a Hydrogen Fuel Cell Electric Car:

Battery (auxiliary): In an electric drive vehicle, the low-voltage auxiliary battery provides electricity to start the car before the traction battery is engaged; it also powers vehicle accessories.

Battery pack: This high-voltage battery stores energy generated from regenerative braking and provides supplemental power to the electric traction motor.

DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

Electric traction motor (FCEV): Using power from the fuel cell and the traction battery pack, this motor

drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions. [4]

Fuel cell stack: An assembly of individual membrane electrodes that use hydrogen and oxygen to produce electricity.

Fuel filler: A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank.

Fuel tank (hydrogen): Stores hydrogen gas onboard the vehicle until it's needed by the fuel cell.

Power electronics controller (FCEV): This unit manages the flow of electrical energy delivered by the fuel cell and the traction battery, controlling the speed of the electric traction motor and the torque it produces. [4]

Thermal system (cooling) - (FCEV): This system maintains a proper operating temperature range of the fuel cell, electric motor, power electronics, and other components. [4]

Transmission (electric): The transmission transfers mechanical power from the electric traction motor to drive the wheels.



Fig. 4. hydrogen Fuel Cell Vehicle [4]

Advantages of hydrogen fuel cell vehicles:

Here are some of the pros of hydrogen FCEVs. [5]

1. Hydrogen fuel cell cars deliver excellent performance with full torque available at low speeds.
2. With no internal combustion engine, an FCEV is quiet in operation. It's an experience similar to an electric car.
3. Another main advantage of a fuel cell vehicle is the quick refuelling time. One can refuel hydrogen in a matter of a few minutes.
4. Hydrogen-powered cars deliver a longer driving range than electric vehicles.
5. The driving range does not depend on the atmospheric temperature. Hence, the driving range does not reduce in cold temperatures.
6. A hydrogen fuel car produces zero carbon emissions as the only exhaust produced is water.

Disadvantages of hydrogen fuel cell vehicles:

Below are some of the disadvantages of hydrogen-powered fuel cell vehicles.[5]

1. One of the significant drawbacks of an FCEV is the lack of hydrogen refueling stations. Since the technology is in its nascent stage, infrastructure development is a big challenge.
2. Since it's a new technology, hydrogen fuel cars are more expensive than their EV counterparts. Hence, you may have to pay a premium price to own an FCEV.
3. FCEVs cabin space gets compromised due to the hydrogen fuel tank. It can eat into the cabin space, especially if it's a small car.
4. The running cost of a hydrogen-powered car is higher than an electric car. That's because hydrogen costs more than electrical energy. However, it may change once there is more demand for hydrogen and production levels go up.
5. A fuel cell car produces zero carbon emissions. However, hydrogen production requires electricity, and if the electricity is produced using fossil fuels, it will ultimately lead to carbon footprints.

While driving, the car emits pure water vapor and filters ultrafine dust from the atmosphere. This fundamental feature of the FCEV has drawn a lot of public attention as the future of eco-friendly mobility. This technology may have a huge impact on our lifestyle in terms of sustainability due to the abundance of hydrogen on Earth and the production process itself being highly eco-friendly.

Overall, FCEVs are cleaner than BEVs and internal combustion vehicles, with additional room for improvement as hydrogen generation and distribution advances. FCEV production is also cleaner than BEV production due to fewer raw material requirements compared to BEV mineral mining and the consumption of heavy metals such as lithium and cobalt. FCEVs are also easier (and cheaper) to recycle than BEVs.

Refer to the table to understand the key differences between hydrogen fuel cell cars and electric vehicles. [7]

Parameters	Hydrogen fuel cell cars	Electric cars
Propulsion system	Electric motor	Electric motor
Power source	Fuel cell	External electrical point
Energy storage	Hydrogen fuel tank	Battery pack
Driving range	Higher than electric cars	Lower than electric cars
Availability of refuelling stations	Low, due to lack of hydrogen refuelling stations.	High, due to the easy availability of charging stations across the country.
Price	Expensive	Affordable than fuel cell cars
Emissions	Zero carbon emissions	Zero carbon emissions

Hydrogen cars vs electric cars:

Fig 5 BEVs and FECVs and comparison [6]

FCEVs are also the best option in terms of environmental impact, as fuel cells can be a 100 percent renewable and environmentally friendly energy system. In the absence of adequate recycling systems, the lithium-ion batteries used in BEVs are expected to cause a serious environmental crisis when they reach the end of their useful lives.

Hydrogen fuel cell vehicles in India:

Some of the Vehicles launched with hydrogen fuel cell are as follows [8]



Fig. 6 Vehicles launched with hydrogen fuel cell [8]

As mentioned earlier, the hydrogen fuel cell is an infant technology. Compared to electric vehicles technology, fuel cell vehicles have a long road ahead. Currently, there are no hydrogen fuel cell cars on sale in India. However, several car manufacturers have shown their intent to introduce such vehicles in India. It will be interesting to see hydrogen car prices in India compared to electric cars.

The Future of Hydrogen Fueled Electric Cars:

It requires further research and development, with electric vehicles needing efficient recycling of spent batteries, faster charging times and increased ranges. Hydrogen, meanwhile, needs improved infrastructure and reduced costs for extraction of hydrogen gas for fuelling.

In the meantime, hybrid options could prove to be a workable solution, but ultimately the goal is to

replace combustion engines to provide a clean, green and renewable transport future.

Conclusion

There are several key differences between hydrogen and electric cars, with each having their own specific advantages and challenges. However, as these challenges are overcome and technology and infrastructure advances, they are both set to be viable options for drivers.

Automotive companies are already investing time and money into developing this next generation of electric and hydrogen-powered vehicles, so we can expect to see them becoming increasingly common on our roads.

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